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ABSTRACT

Evidence from studies of memory for meaningful materials such as sentences and prose passages is reviewed in this paper with emphasis on its implications for the nature of the memory representation. It is argued that models of memory which involve the retrieval of stored copies of originally presented material cannot account for two crucial phenomena: (1) the retention of meaning in spite of losses in memory for specific wording, and (2) the "recall" of information which could only have been obtained by inference. Views of memory which include varying degrees of constructive, interpretive, and reconstructive processes are considered as alternatives to the copy model. These alternatives include theories based on psycholinguistic constructs and visual imagery, as well as positions involving the abstraction and reconstruction of information by means of more general integrative representations. (Author)

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Theoretical Paper No. 48

MEMORY AS A CONSTRUCTIVE PROCESS

by

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Report from the Project on Conditions of
School Learning and Instructional Strategies

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Statement of Focus

Individually Guided Education (IGE) is a new comprehensive system of elementary education. The following components of the IGE system are in varying stages of development and implementation: a new organization for instruction and related administrative arrangements; a model of instructional programing for the individual student; and curriculum components in prereading, reading, mathematics, motivation, and environmental education. The development of other curriculum components, of a system for managing instruction by computer, and of instructional strategies is needed to complete the system. Continuing programmatic research is required to provide a sound knowledge base for the components under development and for improved second generation components. Finally, systematic implementation is essential so that the products will function properly in the IGE schools.

The Center plans and carries out the research, development, and implementation components of its IGE program in this sequence: (1) identify the needs and delimit the component problem area; (2) assess the possible constraints—financial resources and availability of staff; (3) formulate general plans and specific procedures for solving the problems; (4) secure and allocate human and material resources to carry out the plans; (5) provide for effective communication among personnel and efficient management of activities and resources; and (6) evaluate the effectiveness of each activity and its contribution to the total program and correct any difficulties through feedback mechanisms and appropriate management techniques.

A self-renewing system of elementary education is projected in each participating elementary school, i.e., one which is less dependent on external sources for direction and is more responsive to the needs of the children attending each particular school. In the IGE schools, Center-developed and other curriculum products compatible with the Center's instructional programing model will lead to higher student achievement and self-direction in learning and in conduct and also to higher morale and job satisfaction among educational personnel. Each developmental product makes its unique contribution to IGE as it is implemented in the schools. The various research components add to the knowledge of Center practitioners, developers, and theorists.

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Table of Contents

Acknowledgments iv

Abstract vii

I. Memory: Construction or Copy. 1

Memory for Meaning Versus Retention of Wording 2
The Abstraction of a Theme from Prose 3
Psycholinguistic Views of Memory 4
Processes of Inference and Integration in Memory 4
Inference as a Memory Process. 5
Effects of Instructions on Memory Processes. 5
Integration of Information in Memory 6
Characteristics of the Memory Representation in the Bransford and Franks Integration Paradigm 6

II. Visual Imagery in Memory 9

Problems in Separating Mode of Storage from Comprehension Factors 9
Limitations on the Role of Imagery in Integration and Comprehension of Sentences 10

III. From Abstraction During Learning to Reconstruction at Recall . . 13

Remembering: Retrieval or Reconstruction? 14
Memory and Cognitive Structure 15
Age Differences in Constructive Processes 15
Forgetting 16

IV. Summary, Implications for Education, and Future Research . . . 17

Educational Implications 17
Suggestions for Future Research 18

References. 19

Abstract

In this paper, evidence from studies of memory for meaningful materials such as sentences and prose passages is reviewed with emphasis on its implications for the nature of the memory representation. It is argued that models of memory which involve the retrieval of stored copies of originally presented material cannot account for two crucial phenomena: (1) the retention of meaning in spite of losses in memory for specific wording, and (2) the "recall" of information which could only have been obtained by inference. Views of memory which include varying degrees of constructive, interpretative, and reconstructive processes are considered as alternatives to the copy model. These alternatives include theories based on psycholinguistic constructs and visual imagery, as well as positions involving the abstraction and reconstruction of information by means of more general integrative representations.

1
Memory: Construction or Copy?

Like the traces of experience left on Aristotle's wax tablet, the view of memory as a process of producing and retrieving copies of experience has faded only slightly with age. James Mill wrote in 1829, "Our ideas spring up, or exist, in the order in which the sensations existed, of which they are copies [Neisser, 1967, p. 281]." Ebbinghaus and later orthodox experimental psychologists took essentially the same position. The temporal and spatial organization of the input was considered to be mirrored by unmodifiable memory traces which were subject only to strengthening with repetition, to decay with time, or to competition from other traces. In recall, a suitable stimulus reactivated the stored trace. Experience was passively and literally recorded and played back; interpretation did not enter into either phase. Traces remained discrete and unchangeable components of the memory record.

It is often the case that the experimental methods which accompany a theoretical viewpoint are not ideally suited to raising evidence against its general underlying assumptions. When lists of unrelated stimuli such as nonsense syllables were used, the opportunity for the study of alien processes like interpretation or change in recall was limited. Both the input provided and the output requested were in the form of discrete pieces, just as the internal representation was presumed to be. Bartlett (1932) argued against this approach and claimed that the subject's responses to nonsense stimuli, rather than being basic, were more idiosyncratic and odd than responses to common language. "It is impossible to rid stimuli of meaning so long as they remain capable of arousing any human response. . . . This creates an atmosphere of artificiality for all memory experiments, making them rather a study of the establishment and maintenance of repetition habits. To make the explanation of the variety of recall responses depend mainly upon variations of stimuli and of their order, frequency, and mode of presentation, is to ignore dangerously those equally important conditions which belong to the subjective attitude and to predetermined reaction tendencies [Bartlett, 1932, p. 4]."

In order to study naturally occurring memory phenomena Bartlett asked his subjects to recall prose passages rather than lists of nonsense syllables. With connected meaningful material the phenomenon of change in recall emerged. Rather than reduplicating a story verbatim or with assorted words omitted, subjects edited, modified, paraphrased, and reorganized the material in recall. For example, stories about people of unfamiliar cultures were often distorted in recall so that events in the story became more consistent with conventional, probable events in the culture of the subject. Bartlett concluded that a theory involving "fixed and lifeless traces" was inappropriate, since recall was not veridical or fully determined by presented stimuli, but it involved change due to interpretation (not necessarily intentional) by the subject.

To handle these memory phenomena, Bartlett proposed that memory involved not the deposition of discrete traces but the formation of "active organized settings" or "schemata" into which incoming information was incorporated. The schemata did not provide stable pigeonholes into which information was filed piece by piece, but a changing integrated context into which new conceptually related experience was assimilated. Remembering was not accomplished by retrieving a stored item, or even a stored synthesis, but by inferring from the current state of schema what ingredients had gone into it. According to Bartlett, "Remembering . . . is an imaginative reconstruction, or construction, built out of the relation of our attitude towards a whole active mass of organized past reactions or experience [1932, p. 213]." Paul (1967) asserts that the

crucial point of this position is that remembering involves more than the re-excitation of the record, whatever form the record may take. The process is both constructive and reconstructive. As material is presented, it is perceived and interpreted in relation to past experience and assimilated into a schema. Inferential reconstruction occurs at recall. It is a radical position; what is presented (or even perceived) is not what is stored, and what is stored only provides clues about what is to be recalled.

Neisser (1967) takes a similar constructivist position. He argues that naive realism, the notion that the products of perception are copies of external stimuli, has been shown to be inadequate for explaining the perception of speech and visual materials. For example, visual perception involves the continuous integration of many retinal "snapshots" to construct a visual image. In speech perception there is no one-to-one correspondence between the physical stimulus and the phoneme which it indicates to the listener; different sounds are responded to as equivalents, and similar sounds are reacted to differently depending on the context in which they are interpreted. Neisser proposes that information stored in memory has the same type of relationship to recall as external stimuli have to perception: namely, the first allows construction of the second. "Out of a few stored bone chips, we remember a dinosaur [Neisser, 1967, p. 285]." The "bone chips" themselves are the remains of previous constructive activity. These remains evidently include some fragments of content information, as well as information about how construction takes place. Copies of completed constructions such as images or sentences are not stored whole, but are likewise reconstructed.

Memory phenomena are diverse. On the one hand, there is veridical recall of unconnected pieces of information where reconstruction by inference seems unlikely and where what is recalled seems identical in form to what was presented. On the other hand, in memory for connected discourse what is recalled--the "gist," meaning, or paraphrased version of the passage--is markedly different in form (and possibly in content) from the original input. A strict form of copy theory cannot handle such changes in recall, while a reconstructive theory, where no specific traces are postulated, is hard pressed to account for accurate memory for particular facts.

Compromise views have been proposed to handle retention of both specifics and abstracted information. Paul's (1967) formulation involves both traces and schemata. In recall, traces are organized, and the resulting construction is checked against the schema, the conceptually organized setting which reflects previous experience and knowledge of the world. Tulving (1972) suggests a distinction between memory for personally experienced episodes (e.g., a flash of light, a word presented at a particular time, a meeting with a friend) and memory for conceptual semantic information (e.g., propositions like "Gasoline is made from crude oil").

Episodic memory involves retention of specific spatio-temporal information about a signal or event itself, while semantic memory contains information about the referent of a signal regardless of its time of occurrence or form. Both perception and thought contribute to semantic memory, which involves inference and reconstruction, while episodic recall is not dependent on reconstruction from related information. Products of semantic memory can be rehearsed in episodic memory (e.g., a specific sentence expressing reconstructed information could be repeated as an event taking place at a particular time). Ausubel (1963) includes both traces and reconstructive inferential processes in his view of memory for prose. When the learner comprehends poorly and cannot relate new material to previous knowledge, the input is stored in a rote fashion, where its traces remain distinct and separate from those of other information. When the new material can be related to prior knowledge, it is subsumed under known concepts and can be retrieved by reconstructive inference. In this view, given that the material is potentially meaningful, it is the subject's cognitive structure, not the nature of the material, which determines whether storage takes the form of isolated traces or integrated information.

Memory for Meaning Versus Retention of Wording

It is not obvious which one of these speculative views is most adequate; but it is clear that some alternative to the copy approach is needed to explain memory for connected meaningful material, where information is somehow retained in spite of losses in memory for wording. Except for actors and experimental subjects, it is usually the first, rather than the second, which is required. Welborn and English (1937), in a review of 83 experiments, provide evidence for the common sense observation that memory for substance and verbatim memory behave differently. In two representative studies cited in this review, English, Welborn, and Killian (1934) compared substance and verbatim memory for long (1500-word) prose

passages by means of true and false recognition tests given immediately and at intervals from four to fourteen weeks after acquisition. Memory for verbatim items showed loss over time, but memory for paraphrase summary items did not decline; in fact, improvement was noted in some cases. A replication study likewise yielded a significant difference between verbatim and summary items concerning the proportion of subjects who showed improvement over time. One could argue that this difference is due to the fact that repeated testing benefited memory for gist more than verbatim retention, but the authors report other data that suggest that repetition affects verbatim memory more than memory for gist. An experiment by Howe (1970) provides some support for this proposition, in that repeated presentation and testing had little effect in eliminating original errors in both verbatim and substance memory for a short (160-word) passage which was easily comprehended. The use of independent groups tested at different intervals would, of course, be desirable in such a study in order to separate re-testing and forgetting effects.

Memory for gist is also more resistant to interference from interpolated material than is verbatim memory. Sachs (1967) instructed subjects to listen for changes in the meaning (subject-object reversals; negation) and form (active-passive changes and alterations of phrase order that did not affect meaning) of sentences in prose passages. When a recognition sentence was presented immediately after a test sentence, subjects were able to detect changes in both meaning and form, but when other sentences in the passage separated the presentation and testing of the target sentence, recognition for syntactic changes dropped markedly while sensitivity to changes in meaning remained high. Memory for the meaning of a sentence is thus not dependent on memory for its form--a phenomenon that is inconsistent with any theory which proposes that copies of input provide the basis of memory.

Under the usual conditions of sentence comprehension, where the listener is not instructed to attend to formal aspects of a sentence, memory for form can be even poorer than in the Sachs (1967) study. Wanner (in Fillenbaum, 1971) found that after interpolated material, incidental memory for the meaning of a sentence embedded in the instructions approached 100%, while recognition of stylistic changes did not exceed chance. Begg (1971), following Sachs' (1967) procedure, used a continuous recognition paradigm with long lists of unrelated sentences (presented either visually or auditorally). The lists included repetitions of sentences originally presented in the list, as well as sentences changed in meaning or form from the original. The proposition that memory for meaning can be independent of memory for wording was supported.

Welborn and English, in their 1937 review, state, "It now seems evident that any theory of learning is unlikely to prove acceptable unless it is based on investigations with meaningful material [p. 1]." It is with connected meaningful material that problems arise for copy theories of memory. These authors cite evidence which suggest that repetition and serial position--potent factors in rote memory--are not nearly as effective concerning memory for gist. That memory for portions of prose is largely independent of order of occurrence indicates that laws based on rote learning of isolated units cannot be readily generalized to meaningful material. For example, Olson (1971) cites a study by Anisfeld concerning memory for adjective-noun phrases. In a continuous recognition task, subjects were presented phrases which were identical to an original (e.g., back door), phrases with different adjectives which preserved the meaning of the original (e.g., rear door), phrases which reversed the meaning (e.g., front door), and neutral control phrases (e.g., screen door), and judged whether they were old or new. In similar tasks using single words as stimuli, false recognition responses to both synonyms and antonyms were significantly more frequent than to neutral words. When adjective-noun phrases were used, however, false recognition responses were made to antonymous phrases no more often than to neutral phrases, and responses to synonymous phrases were significantly more frequent than responses to neutral phrases. Subjects confronted with two-word adjective phrases were likely to make errors which preserved the meaning of presented material, while those who dealt with single words also made errors which reversed the meaning of the words. The change in unit of analysis from one word to two words resulted in the strikingly different phenomena of rote and gist memory.

The Abstraction of a Theme from Prose

The preservation of meaning in recall appears to involve the process of abstraction of a central theme and selective omission of the information least relevant to that theme. Gomulicki (1956) found that as the length of prose passages increased from 13 to 95 words the size of omitted portions in recall increased from single adjectives to descriptive phrases,

to longer phrases incidental to the central theme, and finally to whole sentences and sections related to secondary themes. As more and more material was omitted, the criteria of importance for inclusion of information in recall became more stringent. Regardless of the proportion of material which was recalled, it contained the parts most relevant to the general meaning of the passage as understood by the subject.

A study by Pompi and Lachman (1967) provides additional evidence for the formation of central themes in memory for prose. Two paragraphs were designed so that, in the experimenters' judgment, the individual words when taken out of context were not related to the general theme of the passage. To design these paragraphs, word association norms relevant to individual words were compared with associations produced by subjects who had been asked to suggest words which, although not included in the paragraphs, were likely to be found in a passage from which the paragraph was allegedly taken. The paragraphs were constructed so that these two sets of associations overlapped very little. The paragraphs were presented in either scrambled or syntactic word order to other subjects who were tested for either recognition or recall. For both methods of testing, subjects who read the meaningfully ordered versions made significantly more thematically related errors than errors unrelated to the theme of the passage, which supports the proposition that memory involves the construction of themes. Readers of the scrambled versions, made an equal number of errors of each type. The larger numbers of thematic errors obtained with the syntactic versions were thus not due to associations between the individual words in the passage and the errors themselves, since the two types of passages differed only with respect to word order. These findings support the authors' proposition that some "surrogate structure"--whether an image, theme, schema, summary, or a combination--is generated from prose materials. This construction is not directly dependent on the meanings of individual words, but on their order in meaningful material--an effect which Pompi and Lachman consider as "perhaps the central mystery of meaningfully connected discourse [1967, p. 143]."

Psycholinguistic Views of Memory

Some attempts to characterize what is retained in memory for meaningful material have made use of the psycholinguistic constructs of deep and surface structure (Sachs, 1967; Blumenthal, 1967). Surface structure refers to the words and phrases of a sentence as perceived by the listener. Deep structure refers to a representation of the gramatical relationships in a sentence, which are not directly indicated by its surface form. In this view, the deep structure of the sentence, rather than the surface structure, is preserved in memory as a basis for semantic interpretation. Clark (1969; Clark and Card, 1969) argues that the semantic features rather than the syntactic distinctions of a sentence are stored, although the deep structure of a sentence must be determined for original comprehension to occur. Both of these formulations treat sentences as separate linguistic objects whose meaning is determined independently of the meanings of other sentences and whose representations remain isolated from one another in memory. With connected discourse, however, memory for information or gist can be independent of retention of both the deep and surface structures of particular sentences.

Processes of Inference and Integration in Memory

Barclay (1973) argues that memory theories which use the individual sentence as the unit of analysis fail to account for memory in situations involving normal comprehension where sentence boundaries are not honored such as the description of a room or an event, where information is synthesized and integrated. Furthermore, comprehension of a sentence may yield information not directly expressed, as in the sentence, "The man stood beneath the platform on which the painter sat." Here the proposition that the man stood beneath the painter is a product of comprehension, yet a linguistic analysis of the sentence itself does not reveal this information. According to Bransford, Barclay, and Franks (1972) sentence memory is a process which involves reconstruction from an abstract holistic representation. The abstract representation of a sentence is constructed by synthesis of information from the surrounding context and by inferences based on general knowledge of the world. Sentence retention is not due primarily to memory for the deep structure and semantic interpretation of an individual sentence, as in the psycholinguistic view, nor is it due to retrieval of the surface structure of the sentence, as in the copy theory of memory. To put it somewhat paradoxically, in the constructive view one goes beyond the information given in a sentence in order to comprehend and retain it.

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Inference as a Memory Process

A study by Bransford, Barclay, and Franks (1972) provides support for the inferential nature of the constructive processes in memory. Two types of sentences were presented auditorily, both of which had identical deep and surface structures but differed with respect to a particular word. For example: (1) Three turtles rested beside a floating log, and a fish swam beneath them; (2) Three turtles rested on a floating log and a fish swam beneath them. Both sentences indicate that a fish was swimming beneath the turtles, but (2) also includes grounds for the inference that the fish swam beneath the log. A recognition sentence was later presented to subjects who had heard either (1) or (2) in which only the final pronoun had been changed from the original: (3) Three turtles rested (beside/on) a floating log, and a fish swam beneath it.

Deep structure and feature theories predict that subjects exposed to (1) or (2) will be equally likely to detect the pronoun change in (3) and call it a "new" sentence. Constructive theory predicts that since (3) is a possible inference of (2), subjects who had heard (2) originally would be more likely than those who had heard (1) to confuse the sentence they originally heard with (3) and label (3) as "old." The results supported the constructive notion of inference as an automatic part of memory. Apparently subjects constructed semantic descriptions of the situation from the presented information and knowledge of spatial relations. They were unable to distinguish the products of inference from information which was actually presented.

Memory for groups of related sentences can also involve inference. Bransford, Barclay, and Franks (1972) read passages such as the following to subjects: "There is a tree with a box beside it, and a chair is on top of the box. The box is to the right of the tree. The tree is green and extremely tall." If semantic descriptions of situations are constructed, sentences such as "The chair is to the right of the tree" or "The tree is to the left of the chair" should be confused with originally presented sentences in a recognition task. If sentences are stored as complexes of features as in Clark's (1969) theory, errors in recognition should favor sentences linguistically similar to the originals but with substitution of the term "left" for "right." The data support the constructive viewpoint: errors which preserved the gist of the situation were predominant.

Honeck (1973) proposes that more abstract forms of sentence storage are possible in which the information stored is at a greater inferential distance from the original sentences than is the case in the Bransford, Barclay, and Franks (1972) paradigm. An example of this distance would be the gap between a proverb (e.g., "A stitch in time saves nine") and what Honeck (1973) calls its parasyntactic paraphrase (e.g., "If you do your work now you'll save yourself a lot of work later"). In a study for memory for unfamiliar proverbs, paraphrased versions which followed the actual proverbs (e.g., the proverb "Reputation is commonly measured by the acre," followed by "People's reputation seems to be more related to their material value than their moral fiber") facilitated both substance and verbatim recall more than did a repetition, a grammatical transformation (e.g., "It is by the acre that reputation is commonly measured"), or an unrelated sentence (e.g., "A reputation may be threatening to those who have it"). The finding that this type of paraphrase (which may be considered as an elaboration, inference, interpretation, or example) improves sentence memory suggests that some type of broad conceptual-semantic memory representation is involved which includes or intersects both the proverb and its paraphrase.

Effects of Instructions on Memory Processes

Barclay (1973) found that some inference processes are under "voluntary control" in that instructions to memorize sentences relevant to spatial (left-right) or relational (taller-shorter) arrays suppressed inferential responses, while normal comprehension instructions, and instructions to generate a mental image of the array, result in the usual prevalence of logically inferrable errors. Similar results were also obtained when recall, rather than recognition, was tested, indicating that constructive effects are not specific to the method of testing. Apparently, different memory representations are constructed depending on the demands of the situation--an effect consistent with Ausubel's (1963) distinction between meaningful and rote learning of the same materials. The findings that different pupillary responses occur under instructions to memorize in contrast to instructions to paraphrase sentences (Stanners, Headly, and Clark, 1972) is congruent with this distinction. Barclay's (1973) procedure, however, involved a comprehension test which came between the acquisition and recall or recognition phases of the experiment. In the comprehension tests, subjects were asked to write descriptions of the arrays, which could potentially be constructed from the acquisition sentences.

Construction may have taken place during such tests rather than as a normal part of comprehension.

Integration of Information in Memory

The process of integration, as well as inference, can be involved in memory. Bransford and Franks (1971) examined the proposition that individuals spontaneously integrate and synthesize information presented in sentences into "ideas" rather than remembering each individual sentence. Bransford and Franks auditorily presented sentences composed of one, two, or three propositions such as the following: (1) "The rock crushed the tiny hut," (2) "The hut was at the edge of the woods," (3) "The rock rolled down the mountain." The propositions could be combined to form one complex "idea sentence" which was never actually presented: "The rock which rolled down the mountain crushed the tiny hut at the edge of the woods." Several sets of related sentences were used, and no two members of a set were consecutive. Before acquisition, subjects had been told that they would be asked to answer questions about sentences which were to be presented. When asked at the time of the test to recognize the actual sentences which had been presented, subjects often mistakenly labelled as "old" sentences which were novel but compatible with the "idea sentence." In fact, the greater the proportion of the main idea that was presented in a recognition sentence, the more confident were subjects that they had actually heard the novel sentence, even though the recognition sentences may have been longer than any they heard during acquisition.[1] When sentences can be meaningfully integrated, the distinctions between them do not seem to be well preserved in memory. The authors conclude that holistic semantic descriptions of situations are the basis for reconstruction of individual sentences and groups of related ones.

Katz (1973) argues that the instructions used by Bransford and Franks (1971) were inappropriate for their studies of the process in which the meanings of separate sentences are combined in memory representations. Instructions which demanded recognition of the actual sentences presented--not of their individual meanings--were used in these experiments. Thus memory for the surface structures of particular sentences was tested when the target phenomenon involved the fate of the meanings of the individual related sentences in memory. Katz (1973) used the Bransford and Franks (1971) paradigm with two sets of instructions: one set identical to those used by the original investigators, and one set which demanded that subjects judge whether sentences presented at recognition meant exactly the same thing as those presented at acquisition. The original finding, that recognition confidence for individual sentences increased linearly with the proportion of the main idea sentence which they included, was replicated with the instructions which required recognition of actually presented sentences. With the "same meaning" instructions, however, recognition confidence was unrelated to the proportion of the idea sentence included in the test sentence. This finding indicates that the linear relationship is not due to semantic processes, and it contradicts the hypothesis that "Recognition of new inputs depends on the number of ideas common to the new inputs and the holistic representation [Katz, 1973, p. 79]." In support of the proposition that this linear effect is not semantically based, Katz reports that in another study using very abstract materials which subjects found "nearly incomprehensible," (e.g. "The original event created an unusual state in the structure of the system"), the effect was also obtained. Furthermore, Reitman and Bower (1973) found similar results with sequences of letters and numbers--clearly non-semantic materials. Apparently without knowledge of Katz's (1973) finding that the linear effect was unrelated to semantic processes and was probably an artifact of procedure, these investigators proposed two theories based on the relative frequency of presentation of individual elements in order to account for the phenomenon. One theory assumed veridical storage, while the other assumed that some kind of prototype was stored. The authors related their findings to those of Bransford and Franks (1971), but the effect they sought to explain appears unrelated to memory for information from related sentences.

Characteristics of the Memory Representation in the Bransford and Franks Integration Paradigm

In the Katz (1973) study, subjects were able to determine whether the meaning of a

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[1] A similar effect occurs with thematic material presented pictorially. Using filmed sequences of people interacting, Knutson (in Cofer, 1973) found high recognition confidence ratings for sequences which had not been presented originally but which were a summation of shorter sequences presented at acquisition.

particular input matched any part of the representation of the complete idea. Katz points out that if the Bransford and Franks hypothesis concerning the linear effect were true, recognition of the meaning of any individual component of an idea would be virtually impossible--a state of affairs which is contradicted by common sense and the performance of subjects in the "same meaning" condition of Katz's (1973) experiment. This finding should not be interpreted as indicating that all portions of presented material are retained equally well, since we have seen that selective omission consistent with preservation of the theme of a passage increases with memory load (Gomulicki, 1956). Rather, when the memory load does not demand deletions, and when the task involves the construction of an "idea" by the addition or combination of propositions which are presented, the liklihood of recognizing a proposition does not depend on the extent to which it exhausts the total meaning of all presented propositions. Combinations of propositions are not preserved in the order in which they are given. Subjects in both conditions in the Katz (1973) study were unable to discriminate old combinations of related propositions from new combinations, and were in fact confident that they were recognizing a sentence which contained all related propositions, even though no sentence of that length had ever been presented. These findings support the hypothesis that related propositions are assembled into a construction which (1) permits access to the informational content of individual components (based on Katz's [1973] findings that in the "same meaning" condition, recognition confidence is not based on the number of elements common to the test item and the "total idea" expressed by the sum of all related propositions) and (2) does not simply mirror the presented organization of the propositions (based on the result cited above regarding the false recognition of novel combinations of propositions).

The Bransford and Franks (1971) paradigm, however, may not bring to light some processes involved in memory for the gist of a passage. In this procedure the "idea" to be constructed was the information contained in a complex sentence which resulted from the summation of separately presented nonconsecutive portions of the sentence. The "idea" was thus not the same as a central theme abstracted from a longer passage. When pieces of information are not merely additive but can be organized in a hierarchy by the learner, the construction of a general theme could allow inferential recognition (but perhaps not recall) of specific propositions that were presented but not actually retained. This process is precluded in the present situation, since one piece of presented information does not provide grounds to infer another. The theme may play a role analogous to that of Ausubel's (1963) construct of cognitive structure, where specific information is first catalogued with respect to more general knowledge, and later undergoes "obliterative subsumption" and loses its identity as it is incorporated into a more inclusive conceptual bin or category.

II
Visual Imagery in Memory

What is stored in memory, according to Bransford, Barclay, and Franks (1972) is an integrated, semantic description constructed from the interaction of linguistic input and previous knowledge. Others (Pompi and Lachman, 1967) have suggested that the memory for theme or sentence meaning could be represented as a visual image. Yuille and Paivio (1969) used similar materials consisting of paragraphs of either scrambled words (nonthematic condition) or normal sentences (thematic condition). They found (as did Pompi and Lachman, 1967) that more words were recalled from thematic than nonthematic paragraphs, but this effect was obtained only when the passages were concrete (i.e., rated by other Ss as relatively easy to image). The authors concluded that imagery may be important to the storage of a theme. It is notable that themes were constructed for syntactic paragraphs under these conditions with concrete materials, but it is unlikely that word order is of no importance in theme construction and memory for longer abstract passages which can be comprehended.

In further support of the imagery hypothesis, Begg and Paivio (1969) found that changes in meaning (subject-object reversals) were recognized more often than changes in wording (synonym substitution) for concrete sentences, but that the reverse held for abstract sentences. This finding is congruent with the results of a study by Begg (1971), some of which were cited earlier as evidence that memory for meaning need not depend on memory for wording. In this study, memory for meaning and memory for wording were found to be independent for concrete, but not for abstract sentences. The authors interpreted their results as support for the proposition that concrete sentences are stored mainly as unitized images which preserve meaning but not wording, while abstract sentences are stored as strings of words. The findings concerning abstract sentences--that memory for wording is superior to memory for meaning--should not be considered as indicating the usual state of affairs with connected material, since unrelated sentences were used. Under these conditions, where sentences are treated as isolated linguistic objects, verbatim memory, rather than construction of a meaningful theme from related sentences, is encouraged (see Barclay, 1973). An interpretation consistent with the imagery hypothesis is that a separate image can be produced from each sentence; hence relatively "word free" meaning retention is possible even with unrelated concrete sentences.

Problems in Separating Mode of Storage from Comprehension Factors

Differences in ease of comprehension, rather than mode of storage, are likely to account for the different effects found by Begg and Paivio (1969) with abstract and concrete sentences. Their measure of comprehension, which did not differ for the two sentence types, was the overall frequency of detection of change (synonym substitution plus subject-object reversals). Johnson, Bransford, Nyberg, and Cleary (1972) argued that ability to detect change does not necessarily indicate comprehension of the sentence. These investigators found that when subjects were asked to rate Begg and Paivio's original materials for comprehensibility, abstract sentences proved significantly more difficult than concrete ones. It would be more difficult for subjects to detect changes in meaning in abstract sentences than in concrete sentences since the abstract sentences were not understood as well originally. Furthermore, subjects' ratings indicated that subject-object reversals changed the meaning less for abstract than for concrete sentences, indicating that detection of such reversals is not an equally sensitive measure of memory for

meaning with both types of sentences. These results do not rule out the imagery hypothesis, but they do indicate that differences in comprehension for abstract and concrete materials must be eliminated before inferences about modes of storage can be made.

A study by Jorgensen and Kintsch (1973) provides further illustration of the problem. Subjects were asked to respond "true" or "false" as rapidly as possible to sentences with concrete nouns as both subject and object. The sentences had been constructed so that some of them were harder to imagine (e.g., "Truck has oil" and "Carrot has stomach") than others (e.g., "Book has cover" and "Rock has hair"). Sentences which had been previously rated by other subjects as highly image-evoking were verified (comprehended and judged true or false) faster than those rated as difficult to image. Imagery instructions had no effect, which can be interpreted as indicating that uninstructed subjects were already using imaginal coding. However, the question remains as to whether high imagery value leads to faster comprehension or vice-versa. The authors point out that imagery value may be a function of the complexity of the memory representation of a word, so that determining the meaning of an abstract word demands dealing with a more extensive network of concepts and relations. Only concrete nouns were used, however, so that the basis of sentence imagery value was the indicated relationship between the nouns. Again determining whether a particular relationship is true or false may be a function of either its imagery value or some other semantic variable. A comparison of the times required to mentally image versus comprehend (one to two seconds) the particular types of sentences used in this study could be helpful in determining the direction of causation (see Paivio, 1971, for a discussion of reaction-time data which indicates the role that imagery may play in comprehension).

Other investigators (Sasson, 1971; Sasson and Fraisse, 1972) have pursued a different line of evidence relevant to imagery processes in sentence memory. Sasson and Fraisse, using both immediate and two-day delay tests, found that interpolated concrete sentences and pictures interfered equally with recall for unrelated concrete sentences. Recall was facilitated equally by interpolated duplicates of original sentences and by pictures which depicted the events described in them. In contrast, neither interpolated concrete sentences nor pictures interfered with recall for abstract sentences, while interpolated abstract sentences did. The authors interpret their findings as support for the proposition of imaginal storage for concrete sentences and pictures, and verbal storage for abstract sentences. If pictures and concrete sentences were stored verbally, they point out, both would be expected to interfere with abstract sentences, which is not the case. A different interpretation is that this lack of interference is due to differences in informational content--rather than mode of storage--between pictures and concrete sentences on one hand and abstract sentences on the other. For example, information about justice might be expected to interfere more with statements about economy than with assertions about a horse, a hill, or a car. Without inspection of the experimental materials, one cannot evaluate the plausibility of this explanation with regard to the present results.

Limitations on the Role of Imagery in Integration and Comprehension of Sentences

In contrast to the above studies where differences between memory for concrete materials and memory for abstract materials are emphasized, Franks and Bransford (1972) found that abstract sentences behaved like the concrete ones used originally in the Bransford and Franks (1971) paradigm, where the information from separate sentences is combined into a holistic representation. In neither case was a string of words retained (as proposed by Begg and Paivio, 1969). Although integration of information from abstract materials can be accomplished without the aid of imagery, the possibility remains that imagery could operate to combine and abstract information from concrete sentences. Bransford, Barclay, and Franks (1972) stress that the inference effect demands the use of previous knowledge (of spatial relations, in this case), not simply picturing information presented in a unit of linguistic input. Processes for "reading" or interpreting a stored image must be proposed as well. The importance of these processes is highlighted when a compound image is presumed to account for the memory representation of several sentences (Yuille and Paivio, 1967), in contrast to the assumption that a discrete image is formed from each sentence.

Clark and Chase (1972), in a study of subjects' comparisons of sentences and pictures, argue on logical grounds that a pure imagery hypothesis cannot account for comprehension or memory of negative sentences. The sentence "A isn't above B," for example, has no uniquely specified image counterpart. To save the imagery hypothesis regarding concrete negative sentences, one would have to propose that some sort of negation tag is affixed to the image.

The authors add that another tag would be needed to specify a point of reference, since it was found that subjects processed "A is above B" differently from "B is below A." The addition of a negative tag seems particularly precarious, since its uses would result in memory for the opposite of what was presented--a rare phenomenon in memory for gist (see Anisfeld, in Olson, 1971, as cited earlier). Perhaps it is no accident that only affirmative sentences have been used in the imagery studies reviewed here. In another experiment Clark (1969) reports that 49 percent of his subjects claimed that they used imagery in solving three-term series problems. The author shows, however, that a spatial image theory designed to account for the solution of such problems (Huttenlocher, in Clark, 1969) fails to account for his data. The image theorist seems faced with the uncomfortable choice of accounting for limited phenomena (affirmative concrete sentence memory) or modifying his construct in vulnerable ways. For a critical appraisal of imagery as a theoretical construct see Pylyshyn (1973); for recent data concerning the spatial properties of the image see Neisser and Kerr (1973).

III
From Abstraction During Learning to Reconstruction at Recall

All of the characterizations of memory representations considered so far (surface structure, deep structure, semantic features, imagery) produce serious logical and empirical difficulties when they are used to account for the way in which information is comprehended and retained from linguistic input. It is evident that something other than copies of presented stimuli is stored, and that this effect is particularly clear when comprehension, rather than verbatim memory is involved.[2] If we do not know the form in which information is stored, is there any evidence concerning how or when in the memory process this information is abstracted, or how the process of retrieval or reconstruction occurs? Gomulicki (1956), as reported earlier, tested for immediate oral recall of prose passages and found that the length of deletions increased with the length of the passage. Since the main theme of a passage was preserved in spite of deletions, the author argued that during learning, subjects abstracted the central theme and deleted information of less importance in order to keep the most essential material within the span of recall. In order to know what could be omitted without jeopardizing the main idea, subjects had to have constructed this central theme during learning, since immediate recall preserved the gist of the passage.

Bransford and Johnson (1972) and Dooling and Mullet (1973) provide additional support for this proposition. They used passages which were extremely difficult to comprehend unless a thematic title or other information which specified the context of the passage was provided. When this was presented prior to the passage, recall (and comprehension which was measured by subject ratings in the Bransford and Johnson [1972] study) was greater than in a no-title control group. This effect was found whether recall was measured in "idea" units as by Bransford and Johnson, or in free recall of words, as by Dooling and Mullet. When presented after the passage, however, the thematic title or context did not affect recall. This finding indicates that processes related to the theme--comprehension, selective omission, integration of ideas, abstraction of gist--occur during the presentation of input rather than at the time of test. These results provide additional support for the hypothesis that what is stored is not a duplication of what is presented. The possibility that once a theme has been constructed the information contained in it can be manipulated at recall is not ruled out by these data.

Potts (1972) obtained reaction time data concerning the verification of relationships between members of four-term series (e.g., A > B > C > D) which had been incorporated in pairs into a paragraph. Responses to remote pairs, which were not presented but had to be inferred, were faster and more accurate than responses to pairs which had actually been presented. This finding is difficult to explain, but it does rule out the possibility of inference at recall, which would have increased the verification times for remote pairs. Potts concludes that inference must have taken place during learning, an interpretation identical to that of Barclay (1973). Potts allowed optional note taking during presentation, however, and Barclay tested comprehension of the series between the presentation and recognition testing of particular pairs--factors which may have shifted or altered the process of inference.

A conclusion similar to that of Potts (1972) and Barclay (1973) was reached by Posner and

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[2] Note that with mnemonic techniques (Reese, 1970) and "Plans for Remembering" (Miller, Galanter, and Pribram, 1960), what appears to be rote memory can involve deliberate constructive strategies.

Keele (1970), who found that memory for central tendencies or base configurations of random dot patterns, which had not been presented but were inferred from presented distortions of the patterns, underwent less loss after one week than memory for distortions which had actually been presented. The authors had predicted this effect from Bartlett's (1932) suggestion that forgetting affects central abstracted information less than peripheral information. If abstraction took place at the time of recognition and was based on memory for the old distortions (originally learned material) losses in memory for the original material would be expected to be accompanied by losses of similar magnitude for memory for inferred central patterns. Such was not the case.

Remembering: Retrieval or Reconstruction?

Abstraction of a theme appears to take place during learning. The generation of inferences from presented information also appears to take place at this time, at least in the situations described above. These findings provide further support for the proposition that what is retained is not a copy of what was presented. Should these data be taken to indicate that since construction occurs during learning, recall in general is not reconstructive but is simply a process of retrieval of part of a stored cognitive product? Three different views of the reconstructive process at recall will be considered. The first is the radical position of Neisser (1967), who maintains that the products of cognitive acts (e.g., images, sentences, themes) are not stored but are reconstructed anew at recall from the results of previous constructive processes. Just as perception of external stimuli does not involve the production of internal copies, when the contents of memory are perceived, they are not copied and simply retrieved at recall. Sasson (1971) provides an interesting counterargument to this position. As was mentioned earlier, he found that interpolated pictures interfered with the recall of unrelated concrete sentences--one of several results which are accounted for by the hypothesis that the sentences were stored as images. That the pictures were also stored in some visual form, rather than verbally, is suggested by the fact that they were presented at a rate too fast to allow verbal description or naming of them. Neisser (1967) argues that images are not stored, but are reconstructed from information which is by definition nonvisual and inaccessible except through the process of reconstruction. If images were not stored from both sentences and pictures, the obtained interferences should not have occurred. It appears that the products of some cognitive acts are indeed stored, and that the type of radical reconstruction process proposed by Neisser does not occur in the present situation.

James, Thompson, and Baldwin (1973) propose that a reconstructive process in individual sentence memory operates on stored information (deep structure relations plus a semantic interpretation) to yield sentences at recall which are similar in syntax to those used in normal conversation. These authors found some support for their hypothesis, in that recall for sentences favored actives over passives, and involved a tendency to start a sentence with the most salient noun in the semantic situation described. Some reconstructive process of this type must also be involved in memory for the gist of a passage, since stored information is not identical to what can be recalled (i.e., various paraphrases of individual sentences or different linguistic expressions of an abstracted theme are possible). In light of previous evidence, abstraction of information from prose takes place during presentation, but recall involves translation or reconstruction of selected information into sentences or other linguistic output.

Reconstruction of originally presented information which was not retained, as well as construction of new information which was never presented, seems possible by means of inference at the time of recall. Rumelhart, Lindsay, and Norman (1972) argue that the latter process is demanded by a question such as, "In the house in which you lived three houses ago, how many windows were there on the north side [p. 199]?" This question involves the problem of how one can know something he did not learn, as Tulving (1972) expressed it. Since such information has never been directly presented, it must be figured out by some inferential process applied to a data base of information actually retained in memory.[3] One must determine which house is involved, find which wall faced north (perhaps by its relationship to the sun or a road of known orientation), and so forth. Information which was actually presented but not retained may be reconstructed at recall. For

[3] Neisser (1967); Miller, Galanter, and Pribram, (1960); and Rumelhart, Lindsay, and Norman (1972) make provisions in their theories for the storage of processes such as inferential retrieval strategies.

example, both abstracted and presented knowledge about the properties of a class include by implication information about the specific members of the class, which does not need to be retained separately for each member since it can be inferred from the fact that a member belongs to a certain class. So far, paradigms have not been used which emphasize this effect as a memory phenomenon, although its role in learning has been investigated (see Klausmeier and Ripple, 1971).

Much of the present treatment of constructive memory has centered around the retention of the gist of connected discourse. To account for complex and varied memory phenomena such as those described immediately above, Rumelhart, Lindsay, and Norman (1972) propose a structured, reconstructive memory system involving labelled and directed associations, concepts, relations, propositions, and search strategies. This theory can account in principle for the inferential and integrative properties of memory (Bransford, Barclay, and Franks, 1972; Bransford and Franks, 1971), as well as the use of memory in problem solving. Kintsch (1972) describes a theory of semantic memory where propositions are the basic units, and inference serves to delete and regenerate redundant propositions and derive words from some more basic type of lexical memory item (see Potts, 1972, however, for evidence that such deletion rules do not account for processing of redundant information). Some empirical support has been found for parts of both models (see Anderson and Bower, 1971, regarding the former; Kintsch, 1972, for the latter).

Memory and Cognitive Structure

Rosch (1973) proposes another theory which is relevant to a fundamental problem in constructive memory--the process of conceptual abstraction. The topic of interest here is not limited to the retention of information presented at some particular time, but involves the nature of the organization and synthesis of previous information in memory which permits individuals to deal with novel and widely varied examples or objects as similar in some important respects. Rosch proposes that classes are acquired naturally on the basis of some constructed central prototype--a kind of "best example" of the class. In this view, class membership is not an all-or-none matter determined strictly by rules about attributes of examples (a view closer to that of Rumelhart, Lindsay, and Norman, 1972), but a system involving a gradient of category memberhip. Relevant experimental procedures include asking subjects how "good" certain objects are as examples of a particular class, and relating these ratings to the interchangeability of the examples in sentence frames--a measure of similarity of meaning. For example, robins, sparrows, penguins, and turkeys are all instances of the class of birds, but a penguin may be technically a bird while a robin is a prime example of "birdness." Instances with similar ratings of "goodness of fit" to a class are treated as similar in that one can be substituted for another in a sentence without producing a semantically peculiar sentence. Similarly, reaction times in sentence verification are shorter for statements about central examples of a class than for examples which are rated as less prototypical. Work with visual materials (Posner and Keele, 1970; Franks and Bransford, 1971) provides support for the prototype model (see Reitman and Bower, 1973, for a discussion of prototype and feature-frequency models). It may be that superordinate classes (e.g., furniture) cannot be characterized by a generic visual prototype, while sub-classes (e.g., chair) can. The general point to be made here is that the structure of memory--whether viewed as Bartlett's (1932) "active organized setting," Ausubel's (1963) "cognitive structure," or the conceptual-semantic network of Rumelhart, Lindsay, and Norman (1972)--is itself a construction which affects the categorization, encoding, and reconstruction of information.

Age Differences in Constructive Processes

Developmental data should be particularly germane to the constructive viewpoint, where previous experience is expected to affect memory processing of new material. Barclay and Reid (1973) used a paradigm similar to Barclay's (1973) design to investigate the role of transitive inference in recall by elementary school children (grades two, three, five, and six). Subjects were presented with sentences which expressed greater-than or less-than relationships between members of a pair, and asked to solve problems which required transitive inference, after which they attempted to recall the sentences. The results (which included an analysis restricted to recall of sentences after correct solution of the problem) suggested that the memory representations of younger children are often fragmentary and self-contradictory, while those of older subjects included both expressed and inferred information and were more internally consistent. Paris and Carter (1973) found that both second and fifth grade children often mistakenly recognized as "old" sentences which had not

been presented at acquisition but which expressed information which could be inferred from the original sentences. For example, the sentence "The bird is under the table" was likely to be "recognized" when the actual sentences presented were "The bird is inside the cage" and "The cage is under the table." False premise and inference statements, on the other hand, were very likely to be rejected, which indicated that the frequent errors in the direction of true inferences were not simply the result of generally poor performance on the recognition test. In this study, second and fifth graders performed similarly, while the Barclay and Reid (1973) results suggest age differences in memory. It may be that transitive inferences are more difficult to make than the spatial inferences which subjects spontaneously generated in the Paris and Carter (1973) study, but the greater difficulty of transitive inferences could not be responsible for the age differences in any direct way, since Barclay and Reid's (1973) conclusions are based on sentence recall data which accompanied only previous correct solution of inference problems. Differences in the type of test used (e.g., recall vs. recognition) may have produced differences in task difficulty which could have caused the difference in results between the two studies. Paris (1973), using a Bransford and Franks (1971) type of integration (rather than inference) paradigm with sentences and meaningful pictures, found that second and fourth grade children demonstrated the constructive memory effect with both types of materials. Perhaps there is some younger age at which children's memory in certain domains is more copy-like than constructive, but relevant data are lacking.

Piaget (1968) proposes that the development of the constructive ("operative," in Piaget's system) type of memory parallels the development of operative schemes (e.g., preoperational, concrete operational, formal). According to Liben's (1973) interpretation of Piaget, "The operative component stores knowledge which has been acquired through the transforming or structuring activities of the organism's operative schemes . . . operative memories are dynamic and subject to revision with changing operative schemes"--a view similar to Bartlett's (1932) general position. Piaget (1968) provides evidence that reproduction memory for a seriated array of sticks and the horizontal level of water in a tilted bottle improves over a six-month retention interval due to Ss' cognitive development which provides a higher level scheme for decoding the original memory. Liben failed to replicate Piaget's finding, using fifth grade Ss, the water level problem, and various needed methodological improvements. Even though Ss improved in operational level of the concept of horizontality (e.g., water level remains horizontal regardless of angle of jar), memory for the original tilted-jar stimuli did not change as predicted. Similarly, Finkel and Crowley (1973) failed to replicate Piaget's finding with respect to memory for seriated sticks. It seems that if the original memory encoding is done when Ss is at a relatively low level of cognitive development, a later increase in decoding ability does not seem to allow S to overcome the effects of the original "impoverished" level of encoding of input.

Forgetting

Theories and evidence have been presented concerning the constructive nature of memory, but the process of forgetting has not been separately treated. Selective encoding and discarding of information during presentation has been described as part of the constructive position, and selective recall congruent with the individual's attitude at that time is a prominent part of Bartlett's (1932) theory, but the question remains as to what happens to the "stored" representation over time. Neisser (1967) considers that such factors as "simple forgetting," retroactive and proactive inhibition, and consolidation are probably not directly relevant to the problems of organization and use of memory (but see Cunningham, 1972, for evidence that retroactive interference can occur with prose). Ausubel (1963) proposes that forgetting is a continuation of the learning process. Over the retention interval, specific information becomes incorporated into representations of more general knowledge, where it finally may become inaccessible. Information that is not meaningful (i.e., cannot be related to what the learner knows) remains as an isolated trace which is subject to whatever factors influence the forgetting of rote materials. Rumelhart, Lindsay, and Norman (1972) indicate that no provision for erasure from long-term memory is made in their theory, and they note that a sophisticated retrieval process must be postulated to deal with incorrect or obsolete information which remains in memory. Other authors reviewed here have been rather reticent on the subject of forgetting. Sasson's (1971) finding, that the representations of concrete sentences and images interfere with one another in memory, indicates that the phenomenon of interference among stored cognitive products should be dealt with in theories of constructive memory if forgetting is not to be ignored.

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IV
Summary, Implications for Education, and Future Research

An overview of the patchwork of evidence presented here indicates that when meaningful material is used, constructive processes must be proposed in order to account for memory phenomena such as the retention of gist and spontaneous inference beyond presented information. Reconstruction at the time of recall involves the translation of stored information into a wide variety of possible sentences or other linguistic products. Recall can also depend on inferential reconstructive processes which take place at that time. The radical view that cognitive products cannot be stored but must be reconstructed anew at recall (Neisser, 1967, as influenced by Bartlett, 1932) is not supported by the limited relevant evidence. The form of the memory representation which permits the retention of meaning independent of specific wording remains unclear, although some construct which transcends sentence boundaries is necessary (see Fillenbaum, 1970, for problems in determining the form of storage in a constructive-reconstructive memory system). Whether prototype, feature, or both types of models of conceptual memory structure will prove adequate in dealing with the naturally occurring process of abstraction of classes from specific instances remains to be seen.

Educational Implications

When memory is taken to include constructive, interpretative, and reconstructive processes, it becomes more difficult to determine what a student will recall from a lecture or text than when it is assumed that what is retained resembles a copy of what was originally presented. If we accept the constructivist position, what can be done to promote accurate recall and comprehension of meaningful material? Memory for prose appears to involve the abstraction of a theme and the selective omission of information of relatively less importance to that theme (Bransford and Johnson, 1972; Gomulicki, 1956). In this process the interpretation and comprehension early in the passage would seem to be crucial in determining how later information is interpreted and whether it is omitted or retained. From this perspective, introductory devices which may enhance comprehension of early portions of a passage and thus guide later interpretation and abstraction (e.g., Ausubel's [1968] "advanced organizers" and Davidson's [1973] concretizing analogies) merit serious consideration. The importance of early comprehension is underscored by Howe's (1970) finding that learners were highly persistent in repeating early errors in prose recall in spite of repeated presentation of the passage.

Paraphrase may be an effective means of improving comprehension and hence theme formation and recall. The greater effectiveness of providing paraphrases as opposed to repetitions of proverbs in a recall task (Honeck, 1973) may have been due to "deeper" or more thorough comprehension of the proverbs caused by the paraphrased versions. The learner's own activities can also be directed to increase comprehension. Barclay (1973) found that instructions to comprehend the passage caused Ss to make a greater number of valid inferences from a passage about spatial relations than did instructions to memorize it. Instructions to paraphrase might facilitate recall for the meaning of a passage in a similar fashion. The constructivist's distinction between verbatim and substance memory is paralleled by the educator's stress on understanding rather than rote learning. In both cases it is emphasized that memory for the meaning of a presentation does not depend on memory for its specific wording. The construction of tests using paraphrase or inference items which measure comprehension, as contrasted with retention of wording, is of crucial concern to both the

teacher and the memory researcher (see Anderson, 1972, regarding the construction of achievement tests which measure comprehension).

Suggestions for Future Research

Although constructive memory effects have been demonstrated convincingly in various experimental paradigms, the lack of systematic manipulation of conventional task variables retards the formation of the empirical base necessary for more explicit characterization of the memory process. For example, prose passages used in memory studies have varied greatly with respect to length, familiarity, and difficulty. The effects of factors such as the number of presentations of a passage, the length of the retention interval, the mode of test (recognition/recall or oral/written), and the type of scoring system used (either verbatim or some kind of substance measure) have not been adequately charted. Mapping out such effects is important in that familiar variables may have unexpected and revealing effects with meaningful materials. For example, repeated presentation and testing are only marginally effective in eliminating original errors of addition and omission in prose recall, which suggests that initial interpretative and coding processes have effects which persist in spite of corrective feedback (Howe, 1970). Similarly, repetition was found to be less effective than paraphrase in improving both verbatim and substance recall of proverbs (Honeck, 1973). This latter finding raises the possibility that some more general representation exists which has points in common with both the proverb and its paraphrase.

Perhaps Howe's (1970) findings are partly due to the fact that the written recall test may have encouraged subjects to pay particular attention to their own responses, so that these were studied more than the oral presentation of the passage. Honeck's (1973) results may be more applicable to unrelated proverbs than to prose. That the highly conventional variable of practice yields unconventional effects with meaningful materials has implications for the memory processes involved, but related studies with alternate testing methods and materials of various degrees of difficulty are clearly needed to establish the generality of these findings.

The rather ordinary variable of passage length may have effects which yield information about the nature of the memory representation. In prose recall, as the length of a passage increases, deletions increase in length from words, to phrases, to sentences, and finally to whole sections of material not crucial to the central theme (Gomulicki, 1956). This effect suggests that as the length of the passage increases, the memory representation becomes more distant from the original and becomes more of an abstracted synopsis than a verbatim transcription. If this is so, the type of interference which occurs between two passages should be related to their length. Intrusions in short passages would be expected to be on the single word or phrase level, while interference among longer passages should be on a more global, abstract, and conceptual level.

Other unanswered questions remain. The description of the sort of abstract memory representation or process which allows translation between pictures and words (Pylyshyn, 1973) and between prose and paraphrase remains a formidable theoretical and empirical task. Whether or not contradictory information is integrated in memory in the same way that compatible sentences are (Bransford and Franks, 1971) is unknown (Burrows, 1971). Developmental changes in constructive processes such as the abstraction of a theme from prose have yet to be explored.

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